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THE BUD-ROT OF CARNATIONS.

BY F. D. HEALD.

A MITE ACCOMPANYING THE BUD-ROT OF CARNATIONS.

BY ROBERT H. WOLCOTT.

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THE BUD-ROT OF CARNATIONS.

BY F. D. HEALD.

INTRODUCTION.

During the past few years a troublesome and destructive disease of carnations has been prevalent in a number of the greenhouses of the state. The disease affects the buds in various stages of maturity and produces a rotting of the petals and other flower parts, at least the parts enclosed by the calyx, thus interfering with the normal opening of the flower. The disease has therefore been termed the "bud-rot" of the carnation.

HISTORICAL.

The bud-rot of carnations was first reported in 1905 by Dr. Wolcott[1]* from specimens received from a greenhouse at Beatrice, Nebraska. He attributed the trouble entirely to a mite which was constantly present in the affected buds. The mite was briefly described as belonging to a new and hitherto undescribed species and possibly a new genus. At this time the fungus origin of the trouble was not suspected. Later in the same year the same trouble was reported to the writer and an investigation was begun. The first examination showed the mites, and in addition the rotting petals were found to be pervaded by the mycelium of a fungus. An examination of the rotting buds led to the belief that the mites were only secondary, and that the fungus was the primary factor in causing the disease. *Fusarium* spores were found upon the rot-

*The reference figures in this article refer to bibliography at end of article, pp. 15–16.

ting petals and it was supposed that the trouble was due to this fungus.[2] It was found later that the trouble was due to a different fungus, and that the *Fusarium* was a contamination which developed during the transit of the specimens.

The bud-rot has been found in greenhouses in Lincoln, Beatrice and Omaha, Nebraska, and is known to occur in the state of New York. The fungus which is the cause of the trouble has been described by Peck[3] and he has examined our cultures and reports as follows:

"I consider the specimens referable to *Sporotrichum anthophilum* Pk. They show the characters nicely."

On Jan. 29th of the present year a letter was received from Professor H. E. Hodgkiss, Geneva, N. Y., asking for information in regard to the bud-rot which was reported in Nebraska. He stated that the accompanying mite or a near relative had been sent to him. The fungus present with the mite was determined by Professor F. C. Stewart, as *Sporotrichum anthophilum* Peck. About April 30th, in compliance with the request of Professor Hodgkiss, specimens of carnation buds affected with the disease under consideration were sent to him by the writer for comparison with the New York specimens. Not until August 21st was the information received that the Nebraska and New York mites appear to be identical.

The carnation is attacked by a considerable number of diseases which affect the roots or stems and foliage, but only a few are known to affect the buds or flowers. The diseases are due in the majority of cases to fungi, bacteria playing a very insignificant part. The following are the principal diseases that have been described:

1. The Stem Rots.—Two different types of this disease have been studied by Stewart[4] and Sturgis,[5] due to a *Fusarium* and to the sterile fungus *Rhizoctonia*. What is probably the same *Fusarium* disease has been studied by Delacroix[6] and the causal organism determined as *Fusarium dianthi* Prill. and Delac. A somewhat similar trouble has

been described by Atkinson[7] under the name of "carnation rosette."

2. Bacterial Spot.—A true bacterial spot disease of the foliage has been described by Woods,[8] while the disease formerly described by Arthur and Bolley[9] as "bacteriosis" has been shown by Woods[10] to be caused by the punctures of aphides and thrips and has been named "stigmonose."

3. Anthracnose.—Three different writers have described an anthracnose of carnations affecting stems and leaves: Halsted[11] found the disease to be due to *Colletotrichum dianthi.* Atkinson[12] attributed the anthracnose which he described to a species of *Volutella.* The anthracnose which Cooke[13] described as occurring in England was attributed to *Gloeosporium dianthi.* It is quite *probable* that the causal organism is the same species in all three cases, but it can hardly be considered as proved in the light of present information.

4. The Fairy Ring.—This disease of carnations has been reported by various writers (Berkeley,[14] Smith,[15] Atkinson[16]), and its common name has been derived from the fact that the fungus produces its fruiting hyphae in concentric zones around the center of infection. While the disease attacks mainly the foliage and stems it has been reported as affecting flowers and buds. Selby[17] mentions the same fungus (*Heterosporium echinulatum* (Berk.) Cooke) as the cause of "leaf and calyx mold" of carnations, which produces unsightly discolorations on calyces and pedicels as well as upon leaves. Sorauer[18] has recorded a case in which the disease seriously affected the flowers. Many buds did not open at all or only slightly, and flowers that did open showed brown dry spots upon the petals due to the growth of the fungus and the accumulation of the spores.

5. Spot of Carnations.—This disease which is due to *Septoria dianthi* Desm. is known to occur in both this country and Europe.[19, 20, 21] The spots are circular or oblong with a dirty white or brown center, bordered by a dark purple band. The central area shows black specks or pycnidia filled with

spores. No mention is made by any writers who have studied this fungus of its occurrence on parts other than leaves and stems, altho it is probable that it may be found on flower parts, at least the calyx.

6. Carnation Leaf Mold.—This carnation trouble has been described by Halsted[22] and attributed to a species of *Cladosporium.* No specific name was assigned to the fungus. The fungus caused a spotting of the foliage and in severe cases the entire leaves or entire top of the plant were affected.

7. Alternaria Disease.—This disease is known to occur both in Europe and in this country.[23] According to Sorauer the trouble first shows as yellow, slightly swollen spots on leaves, stem and calyx. Later the leaf turns brown and is completely killed, while the affected spots show a blackish powder due to the accumulation of *Alternaria* spores.

8. Rust.—This disease (*Uromyces caryophyllinus* (Schr.) Schroet.) attacks carnations at all stages and affects any of the green parts producing the characteristic rust sori. Altho this disease did not appear in the United States until 1891,[24] it is now very generally distributed. It is present to a greater or less extent in nearly all greenhouses.

9. Smut.—Carnation smut (*Ustilago violacea* (Pers.) Fckl.) is not known to occur in the United States except on other hosts.[25]

10. Botrytis Disease.—According to Atkinson,[26] carnation flowers and buds may suffer from the attacks of a *Botrytis.* This trouble is prevalent, especially when the soil and air of the greenhouse are kept too damp. Selby[27] has briefly described the same trouble, but neither writer refers the fungus to a definite species of *Botrytis.*

In the foregoing list it may be noted that the only serious fungus diseases affecting the flowers are due to the fairy ring-fungus and the unnamed species of *Botrytis,* which is probably *Botrytis vulgaris.* In addition to these the trouble known as "petrified buds," which is apparently a physiological trouble, was reported by Kennedy.[28] Arthur[29] has re-

ported an abnormal condition of carnation flowers in which the petals become adherent. No animal or fungus parasites were found to be associated with this trouble.

SYMPTOMS.

The bud-rot of carnations produces effects which show externally, the character depending upon the extent and severity of the infection. The most striking external symptom is the failure of the affected buds to expand into perfect flowers. Carnation benches in which the bud-rot is prevalent generally show a considerable number of flowers that will never open completely. Sometimes the affected flowers deviate only slightly from the normal (Pl. IV, figs. 23 and 24). Flowers which have a split calyx may resemble these superficially in the unfolding of the petals. In buds in which the infection is more severe or begins at an earlier date, the petals become only slightly expanded and the buds die without ever developing into perfect flowers (Pl. IV, figs. 21, 25, 26). If such affected flowers are not picked off, the projecting portions of the petals wither and turn brown and the calyx soon dies also, and assumes a brown coloration. In a few cases the buds are apparently infected at a very early stage, for the calyx does not open sufficiently to allow any projection of the petals, but turns brown and dries up (Pl. IV, fig. 27).

All affected buds show upon closer examination that all or part of the flower parts included within the calyx are affected with a rot which has caused a brown coloration and a softening of the tissues. In some cases the spaces between petals show a whitish hyphal growth plainly evident to the eye, while in other cases no hyphae can be detected without a microscopic examination. When affected buds are broken open, oblong watery-looking objects, 1/12 inch or less in length, are found buried in the soft mass of rotting petals or lying between them. These objects are the distended abdomens of minute female mites, which have been found as constant accompaniments of the fungus. In the earlier stages

of the rot in natural infections the mites may be quite small and inconspicuous, but in well-developed cases of bud-rot they are so evident that they could not be easily overlooked.

ETIOLOGY.

The bud-rot here described has been proved beyond question to be due to a specific organism, *Sporotrichum anthophilum* Peck, which is one of the *Fungi Imperfecti*. The following technical description of this fungus is given by Peck[3] from specimens observed in the state of New York:

"Hyphae creeping, interwoven, branched, continuous or sparingly septate, variable in thickness, .00008–.00024 of an inch in diameter, hyaline, forming a loose cottony stratum; spores globose or broadly ovate, .00016–.0003 of an inch long, borne at the tips of short branchlets which are usually narrowed towards the apex and pointed.

"Parasitic on the filaments and petals of carnation pinks, discoloring them, destroying their vitality and spoiling the flowers. Bayside, Queens Co. Collected by William Bell; contributed by F. C. Stewart."

Since the completion of the manuscript of this bulletin and its submission to the publication committee of the Station, a statement has been received from Professor Stewart, of the Experiment Station at Geneva, New York, concerning the bud-rot fungus. The following is taken from Professor Stewart's letter: "I am confident that the carnation disease we have studied is identical with the one described by you. Our fungus was described by Peck under the name of *Sporotrichum anthophilum*. The specimens you sent us last spring showed the same fungus."

Professor Stewart's statement bearing upon the name assigned to this species should also be noted:

"Notwithstanding the presence of the septate spores I am of the opinion that the fungus should be placed in the genus *Sporotrichum*. Except for the occasional septate spores it is a typical *Sporotrichum*. Moreover, it is identical with the

Sporotrichum poae described by Peck a few years ago from June grass which I sent him (N. Y. State Mus. Bul., 67 (1902) :29). Hence the name of the carnation fungus becomes *S. poae.*"

The mite which is constantly associated with the fungus in affected buds is a new and hitherto undescribed species, but does not belong to a new genus as was at first supposed. A description of this mite is given by Dr. R. H. Wolcott at the end of this bulletin.

The relationship of the fungus and the mite in the production of the trouble has been determined by cultures and inoculations. During the past two years the fungus has been isolated repeatedly from affected buds. In the great majority of cases it was possible to obtain pure cultures by carefully opening the affected buds with sterile instruments, removing small portions of the rotting petals and planting in agar plates. In a few cases cultures were contaminated with bacteria or saprophytic fungi, but the various isolations showed that the *Sporotrichum* existed in the rotting petals in all cases and generally alone. This fact being true, the injury must be due to either the *Sporotrichum* or the mite or the two working together.

In order to determine definitely whether the fungus alone was capable of producing the rot, a large number of inoculations were made, using pure cultures of the fungus. For the inoculations, Lawson carnations were obtained from a house from which the bud-rot was entirely absent. The inoculations were made into large, well-developed buds by making an incision thru the calyx with a sterile lance and passing the needle or forceps charged with the inoculum thru the incision into the interior of the bud. Of the total number of inoculations 83 per cent were successful. The greatest injury and most typical development of the disease was obtained from the inoculation of young buds, that is, in buds that had not begun to show the tips of the petals at the time of inoculation. When partially expanded buds were used,

the inoculation failed or resulted in only an imperfect infection, sufficient to rot the stamens and the claws of the petals to a slight extent. Six to eight days were required for the fungus to become well established in the young buds, and this will explain the failure of the infection when partially open buds are inoculated, since they unfold before the fungus has had time to produce a general infection.

In determining the result of the infection, general appearance and microscopic examination were not relied upon. In many cases it is true that the fungus was clearly visible to the naked eye, but when not visible its presence could always be demonstrated by microscopic examination. In a large part of the artificial infections, the fungus was reisolated in cultures. Such an isolation culture is shown in Plate V, figure 29, in which six separate inoculations were made and each developed without contamination.

Inoculations were attempted, using mites alone without the fungus, but no injurious effects were ever noted to follow except what were due directly to the incisions. It would seem from the failure of these inoculations that the mite plays quite a secondary part in the production of the disease. It is probable that the mite acts as the carrier of the fungus spores as this is the only plausible explanation for the infection of perfectly closed buds. The young mites are actively motile and could easily migrate from one flower to another. Each female produces a large number of young ones and it is apparent that only a limited number of these ever reach other flowers, otherwise the trouble would be more severe. The mites find in the rotting petals a very suitable substratum for their development and apparently intensify the trouble. Experiments to prove definitely the part of the mites as carriers of the disease have been planned and will be carried out, but results will not be obtained in time for this publication.

Sporotrichum anthophilum produces spores very abundantly on all kinds of culture media. Peck's description gives but one kind of spore, but two kinds of spores are al-

ways produced: microconidia,* which are nearly globular or slightly pointed; and macroconidia, which are elongated and generally one septate.

The microconidia are produced in much greater abundance than the macroconidia, and always make their appearance first in the cultures. The spore-bearing branches are generally somewhat clustered and each conidiophore is capable of forming an indefinite number of spores. The conidia are constricted from the ends of the branches, but with the continued growth they may appear in some cases to be lateral, due to the fact that the hypha has grown out beyond them (Pl. I). This manner of growth frequently gives rise to clusters of spores (Pl. I, fig. 1). The microconidia are nearly globular, or slightly pointed at the proximal end, always single-celled and vary from 5.5 to 8 microns in diameter. They germinate at once in water or culture media and give rise to a much-branched septate mycelium (Pl. III, fig. 20). In some cases in crowded cultures the hyphae may give rise to new conidia at their tips without any branching or on very short lateral branches (Pl. III, fig. 18).

The macroconidia are produced less abundantly than the microconidia, but both may occur in the same hanging drop from the same mycelium. One or more spore-bearing branches may grow out from the same cell of the central axis and these have more of a tendency to extend parallel to the central axis or to form a very acute angle with it, while in the production of microconidia the lateral branches are more inclined to grow out at right angles, altho this is not always the case. In the young stages the hyphae and spores are completely filled with a minutely granular protoplasm, but vacuoles soon appear and these become prominent in the course of several hours. The conidia are formed in essentially the same way as the microconidia, but they always become septate. The cross-wall may be formed while the spore is still connected

*The terms microconidia and macroconidia are used for convenience to designate the two kinds.

with the hypha, or its formation may be delayed until after the spores have been completely separated. The successive stages in the formation of the spores as well as the vacuolation of the hyphae are shown in figures 7 to 9, Plate II. The macroconidia are generally two-celled, but sometimes three-celled (rare), elliptical or slightly more pointed at the proximal ends, and vary in size from 4.5 to 5.8 microns x 10 to 17.5 microns. No other spore forms have been found on any culture media, but it may be mentioned that minute pink aggregates of hyphae were formed in old cultures upon corn-meal plates. These aggregates were presumably of the nature of sclerotia or resting bodies.

GROWTH ON CULTURE MEDIA.

The *Sporotrichum* grows well upon all of the common culture media and with but little variation in cultural characters. Upon glucose agar it produces a vigorous growth and soon rises above the surface in the form of a dense cottony mycelium. After the first day or two the medium becomes tinged with pink, and by the time the culture is a week old the color has assumed a deeper hue and may be deep red or madder color. The growth on plain agar is less vigorous and pigment production is entirely lacking or limited to a very faint coloration. On potato tubes and on corn-meal the growth is very vigorous, dense, and even more cottony than on glucose agar, but the pigment production is less marked. All of the regular culture media employed were standardized and had the reaction +10 of Fuller's scale.[30, 31] A slight retarding effect of light upon the growth of the fungus was observed, but no distinct zonation occurred in the cultures grown in the light (Pl. VI).

PREDISPOSING CAUSES.

The bud-rot of carnations is a disease that is not likely to prove troublesome in greenhouses that are kept in prime condition for plant growth. It is rather a disease of neglected

houses, and just as certain human diseases are frequent in unhygienic surroundings, so the bud-rot is a disease that attacks carnations and becomes troublesome when the plants are subjected to unfavorable conditions. Only sporadic cases of bud-rot have ever been observed in the best houses, where proper cultural methods and greenhouse hygiene were practiced.

The first and perhaps the most important factor influencing the development and spread of the disease is the water relation. In all of the houses where the bud-rot has been prevalent the air and soil have been kept too damp. Overwatering, which keeps the soil saturated with water and supplies abundant moisture by evaporation, affords favorable conditions for the development and spread of the disease. This fact has been demonstrated by culture experiments in the greenhouse and is completely corroborated by the examination of conditions in houses where bud-rot has been prevalent.

In addition to the water factor, mention should be made of the unhygienic practices that often prevail in poorly cared-for houses. The accumulation of debris in the form of leaves, trimmings and other plant remains, rotting benches, and decaying organic remains in general, afford favorable conditions for molds of various kinds, and this is especially true for the *Sporotrichum* which is only a facultative parasite.

No varieties of carnations appear to be entirely exempt from the bud-rot. Sporadic cases have been observed on all varieties grown in the houses where the trouble was prevalent. The *Lawson* has suffered more than any other variety and must be considered especially susceptible. The only other variety which has been at all seriously affected is the Queen Louise. Benches of these two varieties growing side by side often have double the number of Lawsons affected.

PROGNOSIS.

The bud-rot does not seriously affect the plant, as the fungus is confined entirely to the buds. It has never been found growing on other parts. The injury is due, then, solely to the fact that affected buds produce deformed flowers or entirely fail to develop. Flowers which upon superficial examination appear only slightly malformed are badly rotted within the calyx and soon wither and die. This fact has been especially noted in the discussion of the symptoms. If the buds have remained without infection until the calyx has opened sufficiently to expose the tips of the petals, subsequent infection will cause but slight injury, as the fungus does not have time to develop before the flower has expanded. In houses where the trouble is severe the buds become infected when quite young, probably when not more than one-half inch long. When infection took place at this early stage, many of the buds rotted before they had time to open, or if they did open at all produced very imperfect and worthless flowers. The actual loss from the disease may vary from a fraction of one per cent to twenty-five or more per cent in badly affected plants. In one small house the grower reported a loss of $1.50 to $2.00 per day from the bud-rot of the Lawson variety.

PROPHYLAXIS AND TREATMENT.

The bud-rot can easily be prevented from becoming severe, if it is introduced into a house, by pursuing the proper measures. The most successful growers of carnations have little to fear from this disease, as conditions in the well-regulated houses are unfavorable for the spread of the disease. Even tho the disease is present it will not become general if proper precautions are observed. In order to test this by direct experiment, Lawson carnations were obtained from a house where the disease was especially prevalent and then grown for a time under conditions as favorable for the disease as

possible, that is, by overwatering and allowing the accumulation of cuttings, rotting buds and other debris. After the disease was well established the watering was made less frequent and a less amount of water was employed, while the benches and surroundings were kept free from decaying organic remains. All affected buds were removed as soon as observed and at once destroyed. By pursuing this method the disease was entirely stamped out. The treatment recommended was followed in one large commercial house with very satisfactory results.

The work which has been carried out up to the present time leads to the conclusion that the disease can be prevented or eradicated if the following measures are carefully heeded:

1. Practice clean culture with the destruction of all refuse that might offer a temporary lodging place for either fungi or mites.

2. Keep the moisture down to the minimum necessary for the healthy growth of the plants.

3. Pick off all affected buds as soon as they appear and destroy by *burning*. Do not under any conditions throw them down on the benches. The benches should be gone over at least every other day until the disease is thoroly under control.

Special thanks are due to the following in carrying out the work outlined in this bulletin: To Mr. H. W. Barre for work upon cultures and inoculations and assistance in making the drawings; to Mr. A. W. Sampson for some of the work upon cultures of the fungus; and to Prof. C. H. Peck for the identification of the fungus.

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EXPLANATION OF PLATES.

All figures in Plates I, II, and III ×680.

PLATE I.

Figs. 1–6.—Various stages in the formation of the microconidia. All drawn from hanging drop cultures in glucose agar.

PLATE II.

Fig. 7.—Hypha showing the beginning of macroconidia, drawn at 9:00 A.M. from hanging drop culture in glucose agar.

Fig. 8.—The same hypha drawn at 11:45 A.M. None of the spores have become septate.

Fig. 9.—The same hypha drawn at 1:45 P.M. Some of the spores have become septate and have reached normal form and size.

Fig. 10.—Hypha bearing conidiophores and macroconidia, drawn at 11:00 A.M. Glucose agar hanging drop.

Fig. 11.—Same conidiophores at 5:00 P.M.

Fig. 12.—Conidiophores bearing microconidia, drawn at 4:30 P.M. from glucose agar hanging drop.

Fig. 13.—The same conidiophores drawn the next morning at 8:00 o'clock.

Fig. 14.—Conidiophores bearing microconidia, drawn at 4:00 P.M. from glucose agar hanging drop.

Fig. 15.—Same conidiophores drawn the next morning at 8:00 o'clock.

PLATE III

Fig. 16.—Group of macroconidia showing variation in form, size and septation.

Fig. 17.—Group of microconidia.

Fig. 18.—Spores that have germinated and are already producing new microconidia (sp.). Taken from a crowded culture.

Figs. 19, 20.—Various stages in the germination of spores and growth of hyphae.

PLATE IV.

Figs. 21, 22, 23.—Open Lawson carnations affected by bud-rot. Flower parts enclosed within the calyx completely rotted.

Fig. 24.—A normal Lawson carnation.

Figs. 25, 26.—Older stages of bud-rot; in fig. 26 the petals have turned brown and shrivelled.

Fig. 27.—An unopened bud of Lawson carnation that has been killed by bud-rot.

PLATE V.

Fig. 28.—A streak plate (glucose agar) of *Sporotrichum* made in form of a square. Direct from bud.

Fig. 29.—Glucose agar plate of *Sporotrichum*. Six separate inoculations made direct from artificially infected bud.

PLATE VI.

Fig. 30.—Glucose agar plate of *Sporotrichum*. 4 days old; incubated at room temperature in dark chamber.

Fig. 31.—Similar to fig. 30 but exposed to light.

PLATE I.

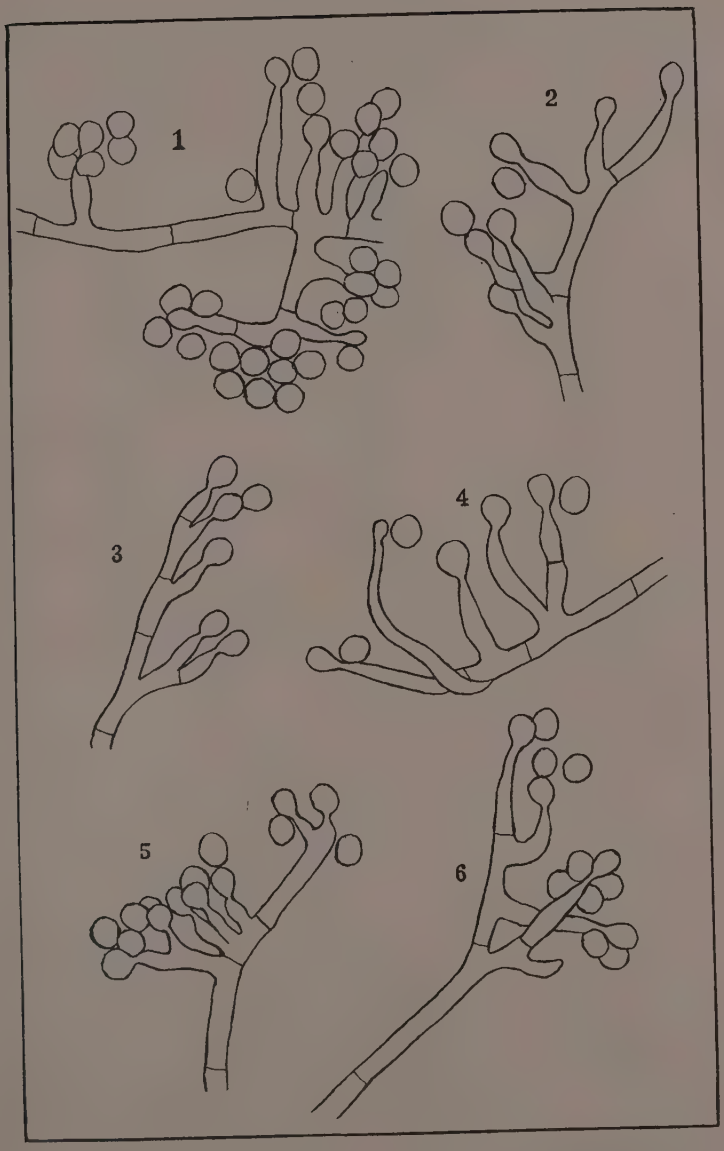

PLATE II.

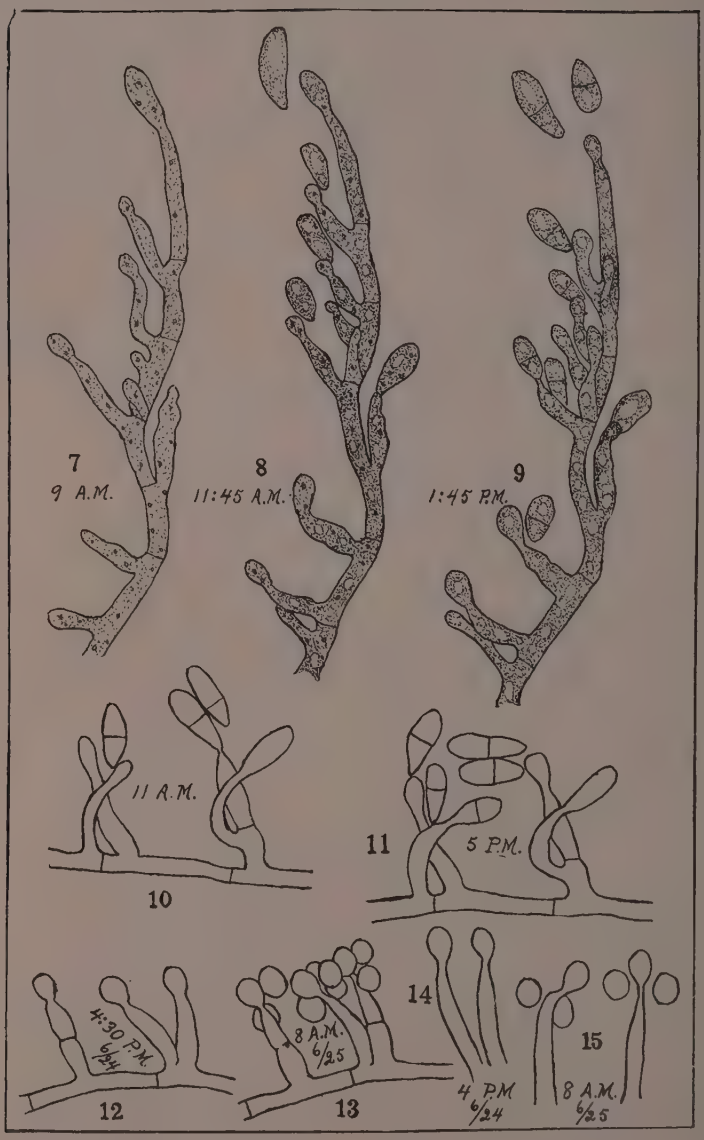
7
9 A.M.
8
11:45 A.M.
9
1:45 P.M.
11 A.M.
10
11
5 P.M.
4:30 P.M. 6/24
12
8 A.M. 6/25
13
14
4 P.M. 6/24
15
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PLATE III.

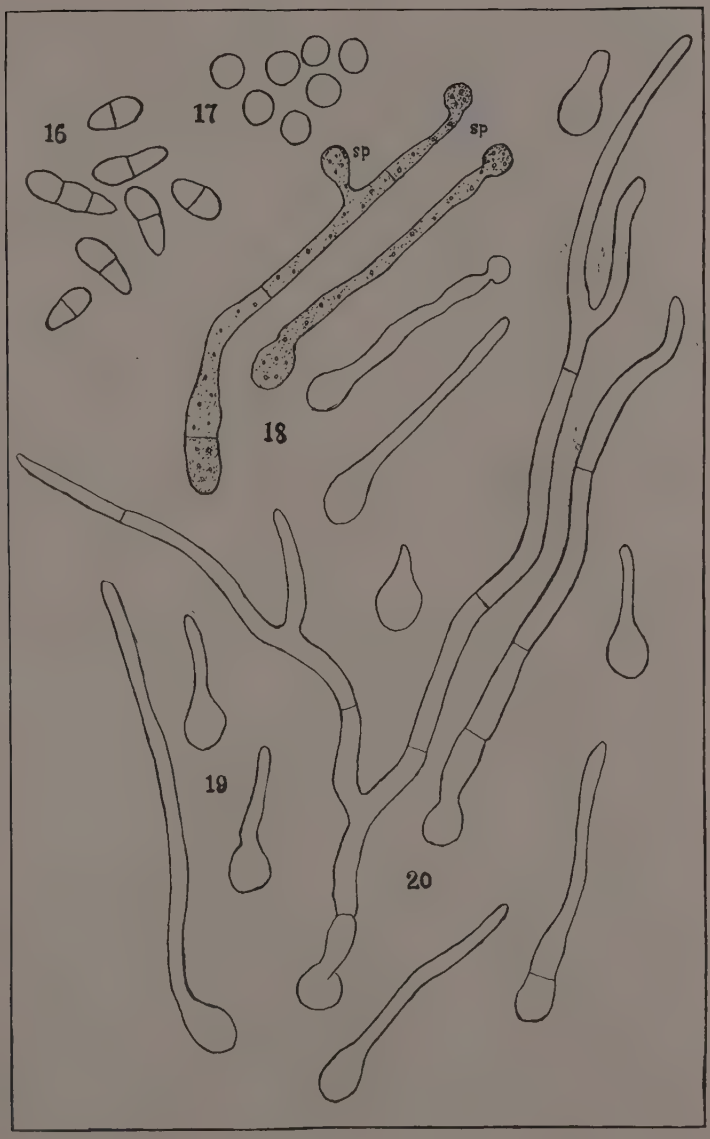


PLATE IV.

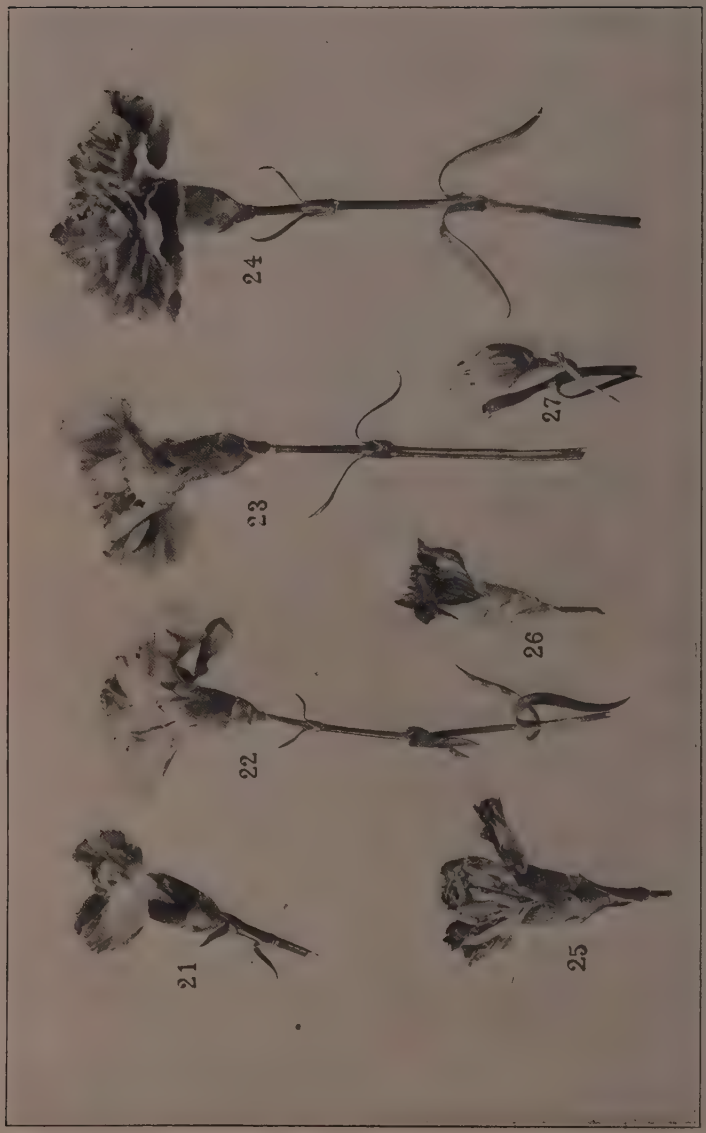
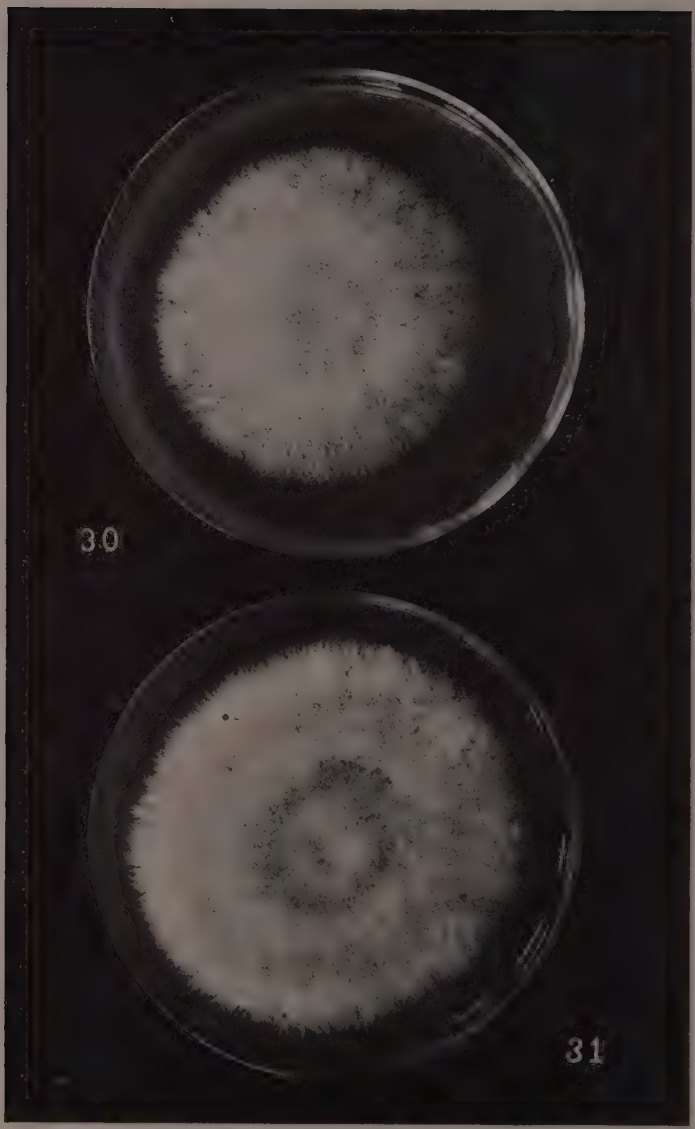


PLATE V.

PLATE VI.



A MITE ACCOMPANYING THE BUD-ROT OF CARNATIONS.

BY ROBERT H. WOLCOTT.*

In December, 1904, there were received from a florist at Beatrice, Nebraska, specimens of buds and blossoms of carnations possessing the appearance described by Dr. Heald as showing the presence of the carnation bud-rot. On separating the discolored, soft, and matted petals, there were seen scattered here and there small white objects appearing like little bladders full of fluid, varying in size from those so small as to be barely visible to the eye to others nearly a twelfth of an inch in length. When placed under the microscope these objects were seen to be filled with eggs floating free in a clear fluid, and on closer examination there was detected at one end of them the fore part of the body of the mite of which the sac formed a part, appearing as a little scar at one end of the sac. Further examination showed the presence of other mites in which the body was not distended as were these referred to, and such showed the characteristic marks of mites belonging to the family *Tarsonemidae* and to the genus *Pediculoides*. The mites have since been reported from Lincoln and from Omaha.

The mites belonging to this genus can be recognized by the fact that the body is soft and elongated, with a distinct capitulum (or "head"), and divided into two portions ("cephalothorax" and "abdomen"), the posterior of which shows traces of segmentation. The legs are in two groups, the anterior two pairs being situated toward the anterior end of the body and the posterior two pairs distant from them and near the posterior end. The mouth-parts are formed for

*Department of Anatomy, The University of Nebraska.

sucking, the palpi are small, and the mandibles stylet-like. There are in the females two club-shaped organs of uncertain use, situated between the two anterior pairs of legs, and near each of these a spiracle opening into an air chamber, neither of these two structures being present in the male. The legs are five-segmented and the second and third pairs each bear at the tip two claws and a sucking disk; the anterior leg has but a single claw and no sucking disk and on the last pair of legs of the male there is also but one claw and no disk. These mites show marked sexual dimorphism. They are ovoviviparous, the young passing through all the stages in development within the swollen body of the female parent. They live as parasites on the bodies of insects, or, as in the case of the mite under consideration, suck the juices from plants.

Aside from the interesting biological relationship existing between the mites and the bud-rot fungus which they apparently distribute and the growth of which in the plant furnishes ideal conditions for the development of the mite, the mites themselves show a number of remarkable biological phenomena, of which perhaps the most remarkable is the mode of development. The female, after fertilization, begins to exhibit a swelling of the posterior end of the body, accompanying the development of the eggs, and within this swollen, sac-like, distended body, the eggs and young pass thru the whole cycle of development and finally there are born from the parent fully mature male and female mites, of the next generation. These pair and the cycle of development is again repeated. In the parent may be seen at the same time eggs and young in all stages of development. Brucker,* in a monograph on *Pediculoides ventricosus* (Newport), has described the male of that species as wandering over the body

*Bulletin scientifique de la France et de la Belgique, XXXV: 365–452, Pls. XVIII–XXI. 1901.

of the gravid female, awaiting the birth of the females of the next generation. During this time he lives parasitically on the older female, and on the birth of the younger females all live as parasites until fertilization has been effected, when the male dies and the younger females leave the parent to begin an independent existence. The young are produced at intervals, a few at a time.

The following is a description of the mite under consideration:

NON-GRAVID FEMALE.—Measures 230 to 240 microns in length, with an average maximum breadth of about 70 microns and a height of about 45. Body thus elongated in form with sides nearly parallel, narrowed anteriorly toward the capitulum and but slightly narrower posteriorly, the posterior end being truncate with rounded lateral angles. The ventral surface, from end to end of the body, is straight or slightly concave, and the dorsal moderately convex.

The body is made up of a capitulum, about 24 microns long, and a body proper, the latter being again divided into two portions by a transverse constriction about 47 microns from the base of the capitulum and just behind the second pair of legs. Traces of further segmentation are seen farther caudad, especially at one level just in front of the third pair of legs. It bears on the dorsal surface a number of slender slightly curved hairs, varying in length and arranged in pairs, the two of each pair being placed toward either lateral margin. Half way between the base of the capitulum and the spiracles and opposite the caudal margin of leg I is one pair 12 microns long; opposite the cephalic margin of leg II and just in front of the spiracles another 120 microns long; and about half way between these two pairs a third 20 microns in length: all of these hairs are directed cephalad as well as dorsad. About 25 microns behind the transverse constriction is a third pair, opposite the cephalic margin of leg IV a fourth, and about half way from this to the caudal end of the body a fifth, each of these pairs being about 20 mi-

crons long: these hairs all point nearly straight dorsad. Only about 12 microns from the caudal end of the body and just in front of the genital opening is a pair of more strongly curved hairs directed caudad, rather stouter than the rest and 75 microns in length, while between them is a pair of short ones only 10 microns long. On the caudal margin is a pair about 12 microns long. Finally, on the ventral surface of the body are a few short pairs placed on the epimera, each about 8 to 10 microns in length.

The spiracles are on the dorsal surface near the lateral margin about 52 microns from the anterior end of the body and opposite the second pair of legs. They are slit-like openings about 5 microns long and lie about 35 microns apart. Just laterad of each spiracle is a club-shaped organ with a slender stalk about 7 microns long and an ovoidal body, broader towards the tip, 11 microns long and 8 broad.

The capitulum is pyriform in shape in dorsal view, the dorsal surface being strongly convex when seen from the side and projecting beyond the ventral, forming thus a sort of a hood for the mouth parts beneath and also a sucker, the opening of which is directed ventrad. The mandibles are stylet-like, short, and do not project beyond this hood, at least in the preserved specimens. The palpi, however, do project beyond the hood a short distance, are movable, and possess a terminal segment of the form of a sharply curved claw.

The epimera of each pair of legs meet in the mid-ventral line; the two anterior pairs of epimera are united and also the two posterior. In the case of the former the sutures are evident, and the caudo-medial angles of the first pair are produced backward between the second. The posterior epimera are less heavily chitinized and the line of junction between them less evident; they are somewhat larger than the anterior ones.

The anterior three pairs of legs are about equal in length. Measuring from the proximal margin of the basal segment

straight along the axis of the extended leg to the base of the claw, they measure from 54 to 56 microns; leg IV is longer, being about 72 microns. They bear a general resemblance to one another, and in each segment 3—counting from the base of the appendage—is the shortest. They are provided with spines of various lengths, most numerous on the distal segment, on which is always one very long hair, and several short stout spines, more or less curved, and a few with very blunt tips. In legs I to III the basal segment is elongated in a direction at right angles to the axis of the body. Leg I is slightly stouter than the rest and has a short spine on the lateral margin of segment 5 and a clavate spine on the same margin of segment 4, near the distal end; on the extensor surface of segment 2 is an extremely long hair, the tip of which reaches to even with the tip of the leg or even somewhat beyond. On segment 4 is another long one, the length of which is not so extreme; segment 5, seen from the dorsal surface, tapers to the tip, but when seen from the side remains of equal width to the very end, the claw being articulated at the disto-flexor angle. Legs II to IV show a gradual constriction of the distal segment from near the base to a little beyond the middle, where the segment becomes very slender; while beyond this is a small bulb-like enlargement at the tip of which are the claws and the stalked sucking disk.

The genital opening is on the caudal surface of the body nearer the dorsal than the ventral margin.

Gravid Female.—In the gravid female the size of the body increases until it may become even eight times the original length; one specimen measured was 1.9 mm. long, 1.2 mm. broad and 1.1 mm. high. The body at first is more ovoidal, but as it becomes greatly distended it becomes ellipsoidal, slightly flattened on the ventral surface. This distension involves that portion of the body lying caudad of the transverse constriction, the dorsal and caudal surfaces being carried farther and farther dorsad and caudad, leaving the two

posterior pairs of limbs nearly in normal relation to the others, but carrying the genital opening clear to the posterior end of the swollen, sac-like body.

MALE.—The body of the male is shorter, broader, and higher than that of the female, varying in length from 140 to 160 microns, in breadth from 80 to 90 microns, and in height from 50 to 60 microns. It is broadest about the middle and tapers from this point in both directions.

There seem to be two transverse constrictions, a second lying just cephalad of the third pair of epimera and about two-thirds the length of the body from the cephalic end. The hairs upon the body are much fewer in number, there being a short distance in front of the transverse constriction two long ones, one toward either lateral margin, and between them and nearer the median line two other shorter ones; while behind the constriction are three pairs, the first very long, the second of moderate length, and the third short. The capitulum is similar in size and structure to that of the female and thus somewhat larger in proportion to the body length.

There are minor differences in the shape of the epimera, while, aside from the characters referred to as generic, the legs show the following characters distinguishing the male: Legs II and III are proportionately longer, leg I measuring 52 to 54 microns, II and III about 62 microns, and IV about 72 microns in an individual of average size. Leg I is also very stout, with the basal segments especially thick, and the distal segment is small, tapers rapidly and bears a very small claw. Leg IV is little stouter than II and III, but segment 5 is thick and not contracted until at the tip, and bears a number of variously modified sensory hairs.

The genital area is crowded into the angle between the last pair of epimera, the medial borders of which diverge caudad, is at the same level as the epimera, and projects beyond the caudal extremity of the body, which lies on a level farther

dorsad. Short spines are borne on the posterior margin of the genital plate.

Only preserved specimens have been available in the preparation of this description, but the material was preserved in several fluids—alcohol, formol, corrosive sublimate, Carnoy's acetic-alcohol, picronitric, and Koenike's solution.

The mite appears to belong to a species hitherto undescribed and may appropriately be designated *Pediculoides dianthophilus.*

EXPLANATION OF PLATES.

PLATE VII.

Fig. 32.—Female, dorsal surface. Magnified 460 diameters. Drawn with camera.

Fig. 33.—Male, dorsal surface, x460. Camera.

Fig. 34.—Female, partly distended with eggs and young. Seen from the side. x95. Outline with camera. Specimen preserved in alcoholic corrosive sublimate.

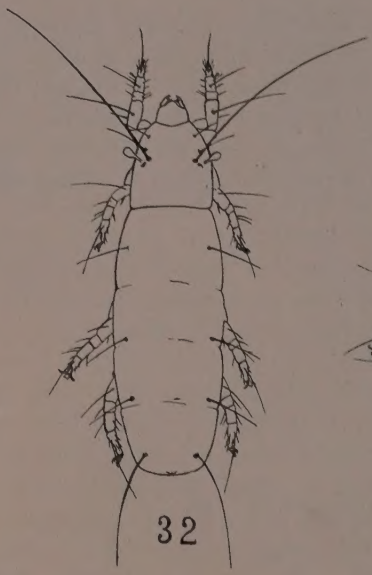
PLATE VIII.

Fig. 35.—Female, ventral surface, x460. Camera.

Fig. 36.—Male, ventral surface, x460. Camera.

Fig. 37.—Female, fully distended, from ventral surface, x80. Outline with camera. Specimen preserved in alcoholic corrosive sublimate.

PLATE VII.



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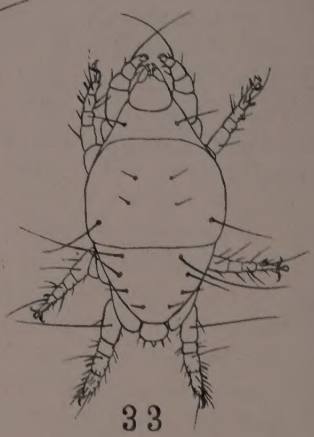

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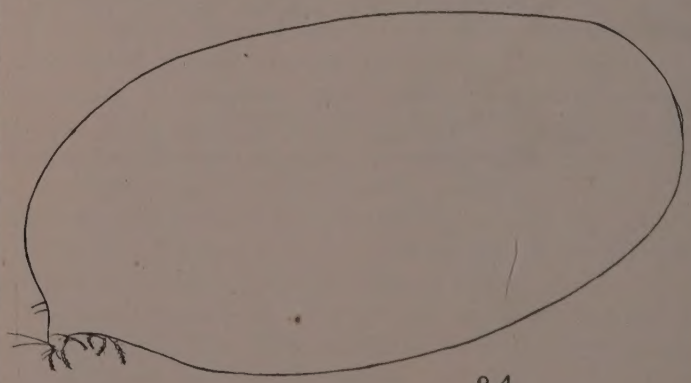

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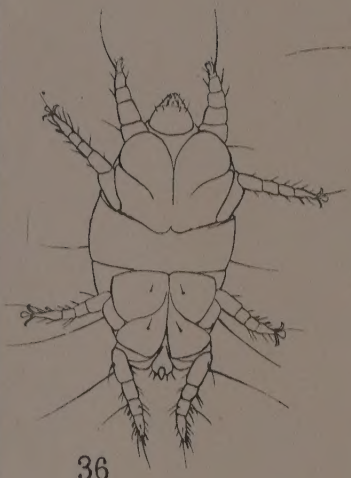
PLATE VIII.



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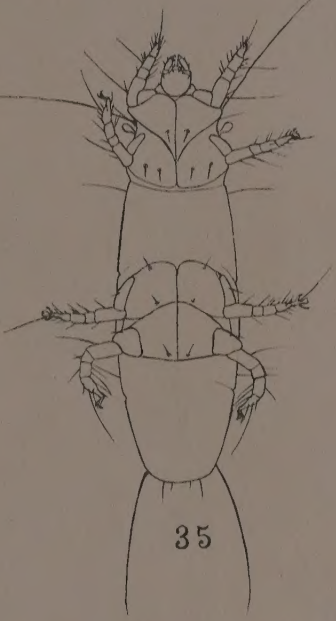

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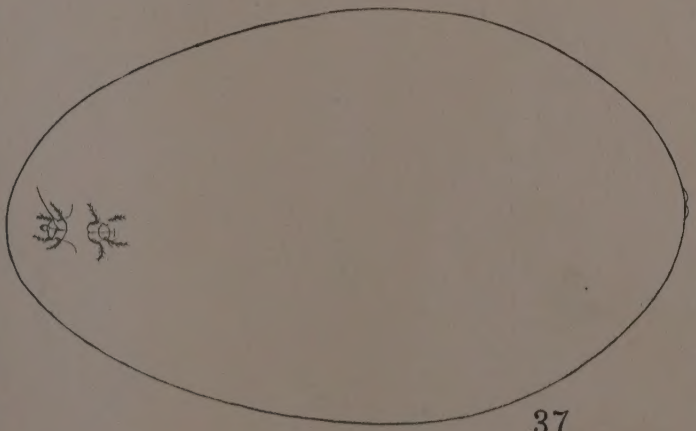

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